Membrane Technology & Research, Inc.

Membrane System for Recovery of Volatile Organic Compounds from Remediation Off-Gases

Technology Need:

Many Department of Energy (DOE) sites are responsible for the treatment of soil, groundwater, and various other wastes that contain volatile organic compound (VOCs). Treatment of these waste typically results in a VOC-contaminated air stream. Treatment processes, such as air stripping and steam stripping, generate VOC-laden off gasses requiring treatment. Remediation technologies such as soil vapor extraction, and air sparging also generate VOC-laden off-gasses. The baseline technologies for the treatment of VOC-contaminated off-gasses are activated carbon adsorption and catalytic thermal oxidation. Innovative technologies are needed that can remove VOCs from off-gasses more cost effectively than the baseline technologies.

Technology Description:

Membrane Technologies and Research, Inc. (MTR) has developed an innovative, membrane-based treatment technology for the removal of VOCs from remediaiton off-gasses. MTR's technology separates the organic components of an off-gas stream using a membrane that is more permeable to VOC's than air. The membrane, termed "permselective", is designed to selectively allow hyrocarbons to permeate the membrane more easily than air. The process separates the hydrocarbons, resulting in a concentrated VOC liquid (permeate) stream and VOC-depleted air stream. A treated water stream is also generated if an appreciable amount of water vapor is present in the off-gas. The VOCs in the treated air stream and water stream are reduced to less than 10 parts per million (ppm) and 1 ppm VOC by weight respectively. An illustration of showing how the permselective membrane works is presented in Figure 1. In this figure the larger circles represent hydrocarbons selectively permeating the membrane.

Removal of VOCs from air streams with membranes is a relatively new technology. To date, most membrane systems have been installed on process streams in the chemical and petrochemical industries. Off-gases produced in DOE remediation operations contain lower VOC concentration than those found in chemical-plant process streams. MTR's membrane separation technology is best suited to air streams containing VOC concentrations above 100 ppm.

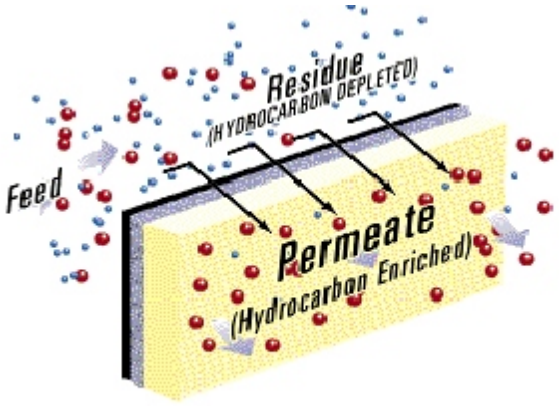

Figure 1: Permselective Membrane.

Benefits:

- Condenses VOCs into liquid, decreasing overall waste volume.
- Applicable to off-gasses containing non-chlorinated, chlorinated, and flammable VOCs.
- Requires only a source of electricity for operation.

Status and Accomplishments:

This two-phased project concluded in June 2000. The demonstration of the technology was conducted between March 1999 and February 2000 at the

McClellan Air Force Base (AFB), National Environmental Technology Test Site (NETTS), located outside of Sacramento California. The demonstration system removed chlorinated VOCs from the off-gas from a soil vapor extraction (SVE) system. Operational conditions are summarized below:

- Design flowrate:100 standard cubic feet per minute (scfm).

- VOC concentration in SVE off-gas: 101 ppm

- Target VOC concentration in treated off-gas: 10 ppm

The results of the demonstration were mixed. The system exhibited the ability to remove VOC to the target level, but two significant performance issues were also encountered. First, the presence of carbon dioxide (CO_2) in the SVE off-gas at one to three percent was found to reduce the system's capacity (flowrate) by a factor of two to four. The CO_2 is produced from biodegradation of organics in the subsurface. The CO_2 is problematic because it, like the VOCs, is permeable to the membrane. The presence of CO_2 was not anticipated and was not incorporated into bench-scale testing. The second problem encountered was fouling of the membrane modules with oil and water due to a mechanical failure, which resulted in deteriorated separation efficiency within two weeks.

Another shortcoming of the membrane system that became evident through the demonstration was cost. A cost analysis was performed after the demonstration, comparing the cost of the membrane separation technology to the cost of carbon adsorption (with both off-site regeneration and on-site steam regeneration) and catalytic oxidation. The results of the cost analysis are summarized graphically in Figure 2. Based on the results of the cost analysis, the membrane process is more cost effective than activated carbon with off-site regeneration at concentrations above 100 ppm, but catalytic oxidation is much more cost effective than the membrane separation technology over the range of VOC concentrations expected for remediation applications.

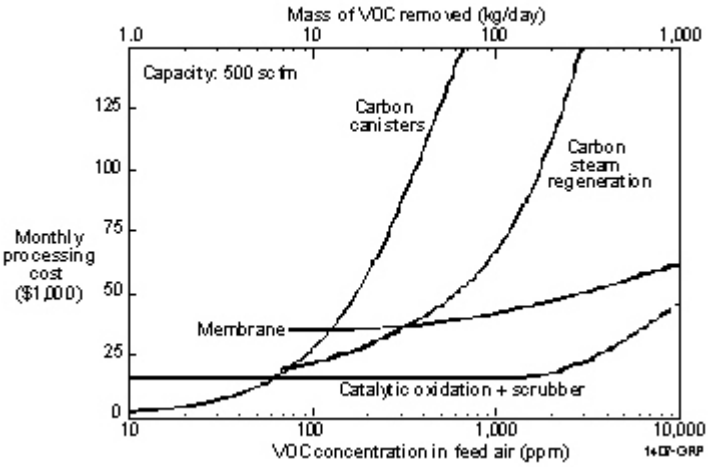

Figure 2: Processing costs as a function of VOC concentration the membrane separation system and competing technologies.

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Online Resources:

Office of Science and Technology, Technology Management System (TMS), Tech ID # 266
http://ost.em.doe.gov/tms

The National Energy Technology Laboratory Internet address is http://www.netl.doe.gov

For additional information, please visit Membrane Technology Research, Inc.'s website at http://www.mtrinc.com/index.html